



F-35 Corrosion Program

Kyle Russell



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Fleets F-35 will Replace

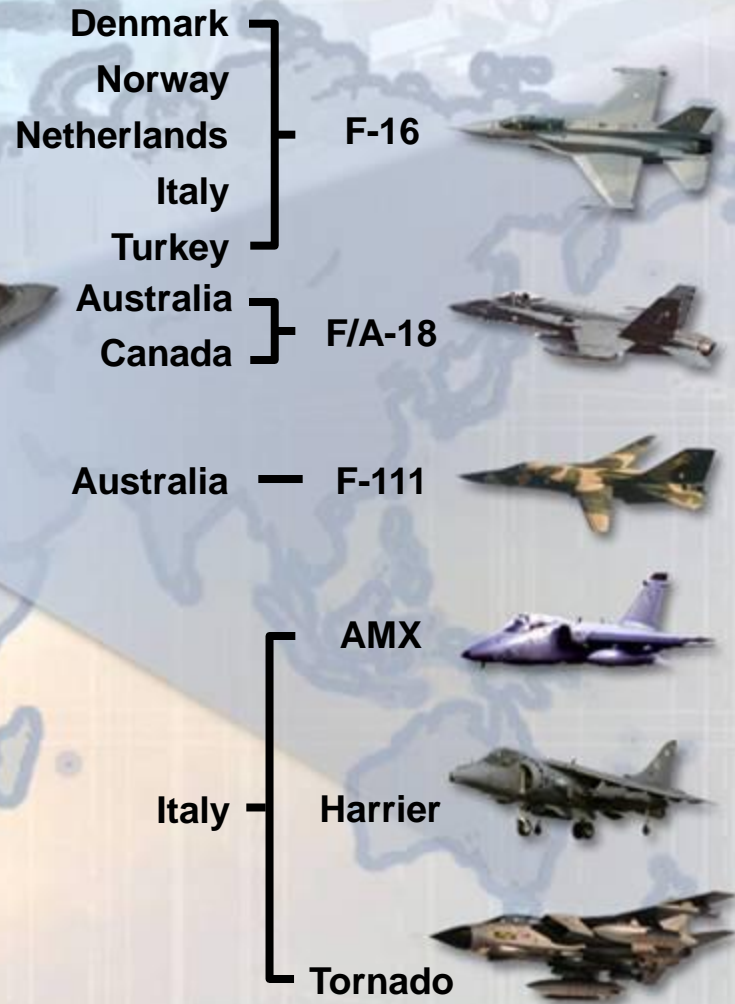


Domestic and UK



**F-35
Joint
Strike
Fighter**

International





JSF Family Of Aircraft

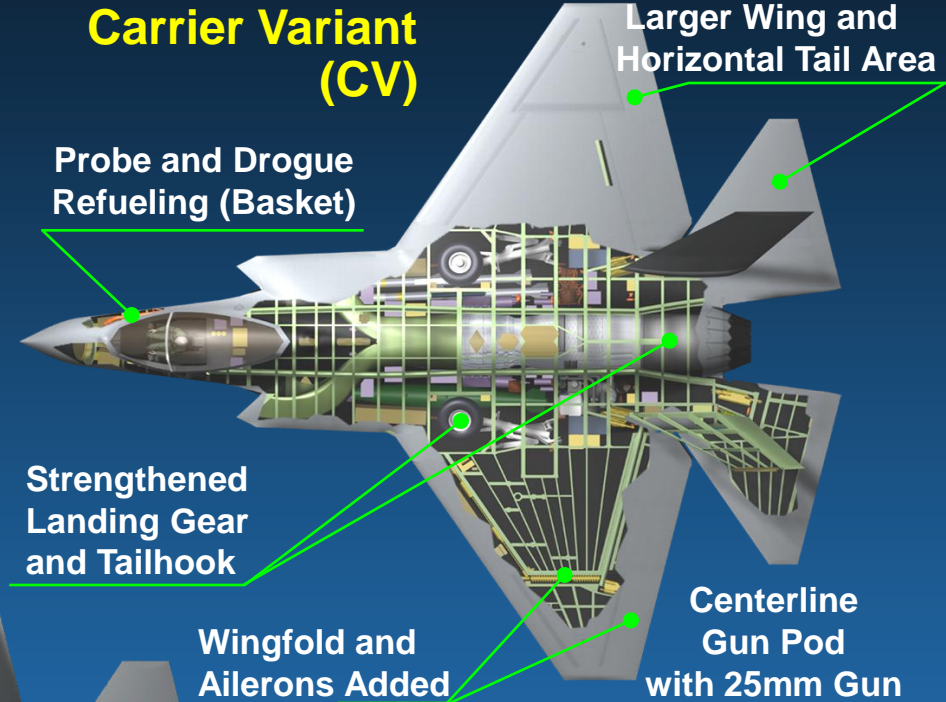
One Program -- Three Variants
Meeting Service and International Needs



Conventional Take-Off and Landing (CTOL)



Carrier Variant (CV)



Short Take-Off and Vertical Landing (STOVL)



3-Bearing
Swivel Nozzle

All variants

- 450-600 nm Range
- 1.6 Max Mach (Limit)
- Stealthy
- Same Weapons
- Similar Avionics
- Similar Flight Envelope
- Same Basic Engines



F-35 Characteristics



- **Key Attributes:**
 - ***Stealth***
 - ***Integrated Avionics***
 - ***A/G Munitions***
 - ***Intraflight DL***
 - ***Adv A/C Survivability***
- **General Features**
 - ***Single seat***
 - ***Speed: 750 kts or 1.6M***
 - ***Ceiling: 50,000 ft+***
 - ***Engine: PW F135; FET F136***
- **Sensors**
 - ***Fully integrated open architecture system***
 - ***A/G – A/A radar/SAR***
 - ***Electro Optical A/G Targeting system***
 - ***A/A IRST***
 - ***Electronic Support Measures (ESM)***
 - ***Short range EO spherical coverage***



Length: 51.4 ft
Wing Area: 460 ft²
Weight (Empty): 29,036 lbs
Internal Fuel: 18,840 lbs
Range: 600 + nm

Length: 51.1 ft
Wing Area: 460 ft²
Weight (Empty): 32,161 lbs
Internal Fuel: 14,003 lbs
Range: 500 + nm

Length: 51.4 ft
Wing Area: 668 ft²
Weight (Empty): 32,072 lbs
Internal Fuel: 20,085 lbs
Range: 600 + nm

LETHAL SURVIVABLE SUPPORTABLE INTEROPERABLE



JSF Team

Prime and Major Sub-Contractors



NORTHROP GRUMMAN

- Center Fuselage
- Weapons Bay Door Drives
- Arresting Gear
- Carrier Version (CV) Control and Test
- Radar
- Software
- Low Observable Support System
- Training Courseware and Management Systems

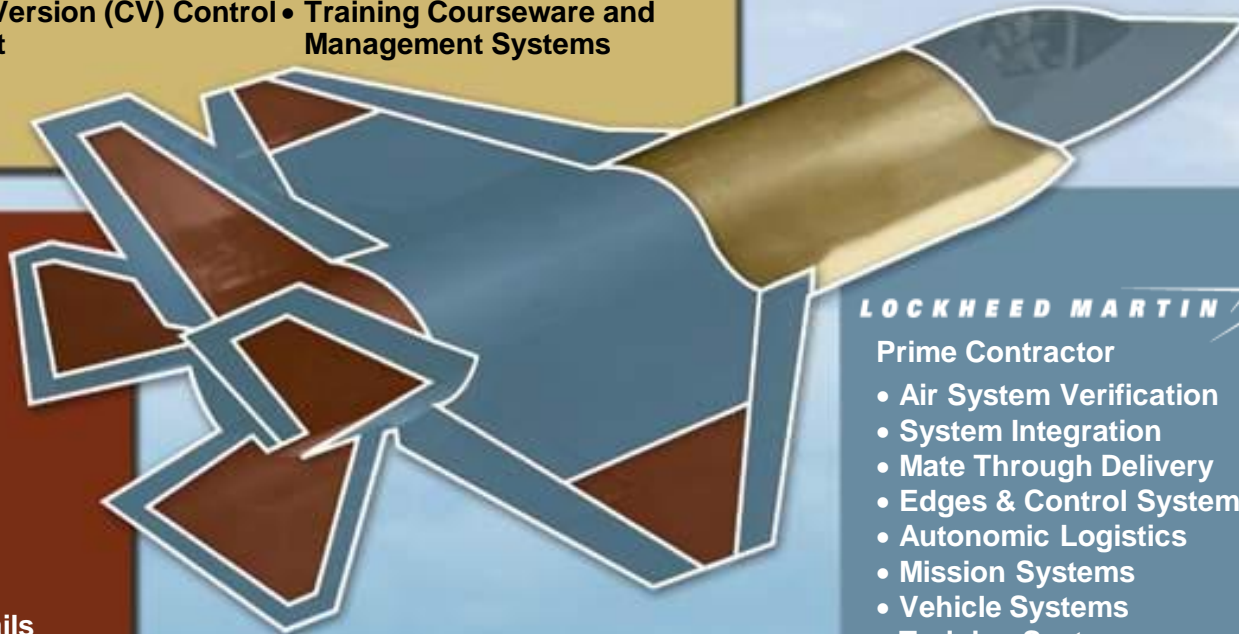
BAE SYSTEMS

- Aft Fuselage
- CV Wing Fold
- Fuel System
- Crew Escape
- Life Support
- EW System
- U.K. Support Center
- Throttle/Side Stick
- Horizontal/Vertical Tails
- Flight Control Computer
- STOVL Control and Test
- U.K. Rqts/Stores/SW

LOCKHEED MARTIN

Prime Contractor

- Air System Verification
- System Integration
- Mate Through Delivery
- Edges & Control Systems
- Autonomic Logistics
- Mission Systems
- Vehicle Systems
- Training System
- Forward Fuselage
- Wing





The Pipeline



- Approximately 100 Aircraft in Flow (LRIP 1 – LRIP 5)
- Will Have Fielded ~ 50 Aircraft by The End of CY12
 - *Will need pilots and maintainers trained through the ITC to support Fleet expansion*



Academic Training Center



JSF Squad Ops/AMU Hangars



Corrosion Program



Background

- **HASC directed OSD Office of Corrosion Policy and Oversight to conduct an evaluation of the F-35**
 - *Corrosion Evaluation Team (CET) assembled*
 - *Conducted site reviews at JPO and 5 contractor facilities*
 - *Similar reviews were also conducted at F-22 sites*
- **CET findings reported back to the HASC**
 - *Drawn extensively from F-22 lessons learned*
 - *F-35 JPO response provided as an attachment to the report*



CET Finding Change Management

- **CET Concern:** Risk that equipment tested to lower corrosion requirements based on location will not be re-qualified to standard corrosion requirements if location or orientation is changed.
- **JPO Response:**
 - *CM Plan requires JPO concurrence of Major B changes*
 - *JPO participates in LM Change Request (CR) technical reviews*
 - *All changes affecting materials must be evaluated by M&P IPT*
 - *Changes potentially affecting corrosion are reviewed at F-35 Corrosion Prevention Advisory Boards (CPAB)*
 - Includes equipment location changes
 - *Many opportunities to identify risk resulting from change*

**Program has Insight into Changes Affecting Corrosion -
Has Taken Recent Action to Participate in Early CR Reviews**



CET Finding Use of Magnesium

- **CET Concern:** Aircraft magnesium components are interfaced with aluminum engine anodized gearbox which is not primed/top-coated.
- **JPO Response:**
 - *Magnesium components are coated with best practice coatings*
 - *Additional surface barrier requirements being pursued for gearbox*
 - *There are very few Mg components on the aircraft*

**Program Acknowledges CET Finding –
Is Pursuing Additional Surface Barrier Protection on the Gearbox**



CET Finding Use of Magnesium

- **CET Concern:** Components qualified by similarity rather than test.
- **JPO Response:**
 - ***Most challenging component was tested by full-scale testing***
 - Chosen based on geometry, environment, location
 - ***Design incorporated best performing coating based on test results***
 - Other components were qualified by similarity using updated coatings
 - No additional testing is currently planned
 - ***JPO and LM continually evaluates new coatings/technologies for future improvements***

**Program Qualification Testing Approach Effective -
Thorough Assessment of Most Challenging Component**



CET Finding

Use of Non-Chromated Paint

- **CET Concern:** Use of water-borne non-chromated primer, especially in non-inspectible areas.
- **JPO Response:**
 - *Primer selected in 2004 tested to military coating spec requirements*
 - Best non-chromated primer (with low VOCs) available at time
 - *Initiated independent testing of baseline primer to failure to compare to legacy chromate failure modes (2010)*
 - May increase required inspections if baseline primer with topcoat is not as effective as 1-2 coats of chromate primer used on legacy
 - *White topcoat is used in all fuselage bays—further reducing risk*
 - *Use of chromated primer in non-inspectible areas still under review*
 - *Assessing DoD/industry R&D efforts of other non-chromated primers*
 - Pursue improvement if/when technology readiness warrants



CET Finding Flexure Testing

- **CET Concern:** Corrosion Testing does not include fully representative operational situations (flexing of joint under loading conditions).
- **JPO Response:**
 - ***Conductive gap filler qualification testing included severe spectrum fatigue testing as part of environmental testing***
 - Most susceptible coating component to cracking on legacy platforms
 - ***Representative coatings/gap filler on CG-1 full-scale drop test***
 - Inspections of critical joints have shown no significant damage to coatings during severe aircraft carrier landing conditions
 - ***Representative coatings/gap filler installed on F-16 flight test bed***
 - Inspections have not shown joint issues
 - ***F-18 carrier-based flight testing of LO topcoat in-work***
 - ***There is no current test standard to perform this test***

**Program Acknowledges Legacy Program Challenges –
Has Taken Steps to Minimize Risk via Surrogate Platforms**



CET Finding Full Scale Climatic Testing

- **CET Concern:** The climatic test may be cut/reduced in scope and may not fully test drainage and corrosion performance.
- **JPO Response:**
 - *The program **will not** reduce climatic test duration / scope*
 - Validated during Summer 2010 Tech Baseline Review
 - Decision made after completion of CET site reviews
 - *Will incorporate legacy program lessons learned*
 - Specific interest in assessing internal drain paths

**Program Actions Have Mitigated CET Concern –
Robust Climatic Test Planned Incorporating Lessons Learned**



CET Finding Life Cycle Cost Methodologies

- **CET Concern:** Life cycle cost assessment methodology used for trade studies does not specifically account for corrosion impacts.
- **JPO Response:**
 - *Program method is a parametric based on multiple legacy programs which does not specifically break out corrosion*
 - Similar to methods used for other legacy programs
 - *Will continue to pursue improved modeling*
 - Surveyed Office of Corrosion Policy and Oversight website
 - Working with the CET did not realize better LCC models
 - Will assess whether current legacy program realities can influence current parametric based models

**Program Acknowledges CET Concern –
Will Continue to Work with OSD to Improve Techniques**



Lessons Learned from F-22

- **Design**
 - ***Reduced use of conductive gap fillers***
 - Fewer than 25% of permanent gaps use conductive gap filler
 - ***OML coatings/materials use that are not galvanically dissimilar***
 - System requirements retain risk—not as dissimilar as F-22 baseline
 - ***Ensure sufficient internal drainage system***
 - ***Specific use of design best-practices to minimize corrosion:***
 - Elimination of aluminum honeycomb
 - Fiberglass barrier ply at composite/aluminum interfaces
- **Process**
 - ***Greater participation in industry change management process***
 - ***Integration of “standard” and signature M&P communities***
 - ***Active management and use of CPAB expertise***
 - Active participation in F-22 CPAB exchanges



Lessons Learned from F-22



- **Test**

- *Inclusion of sulfuric salt spray and increased neutral salt spray for materials and systems qualifications*
- *Early corrosion testing of conductive gap filler in a representative operational environment.*
- *Extensive testing of full stack-up panel seams with simulated damage exposed to accelerated and outdoor (beach) exposures*
- *Maintaining a robust full scale climatic test*

**F-22 Lessons Learned Have Been Realized –
Many Industry/Government SMEs Have Transitioned to F-35**



Summary



- The F-35 has a comprehensive corrosion prevention program
 - *Leveraged legacy aircraft **design lessons learned***
 - ***Integrated the best processes from Navy and Air Force standards***
 - *Focused on early assessment of materials in an operational environment*
 - ***Maintains active engagement in technology development communities***
- The Summer 2010 Technical Baseline Review validated approach
 - ***No significant gaps in design or testing were identified***
- Corrosion is always a systems engineering trade
 - *Suggests a “corrosion-proof” aircraft is unlikely*
 - ***Resulting “corrosion-resistant” design improved over legacy LO aircraft***
- The CET required the JPO to broadly review/defend prior decisions
 - ***Technical consensus of findings did not occur in all cases***



Questions?